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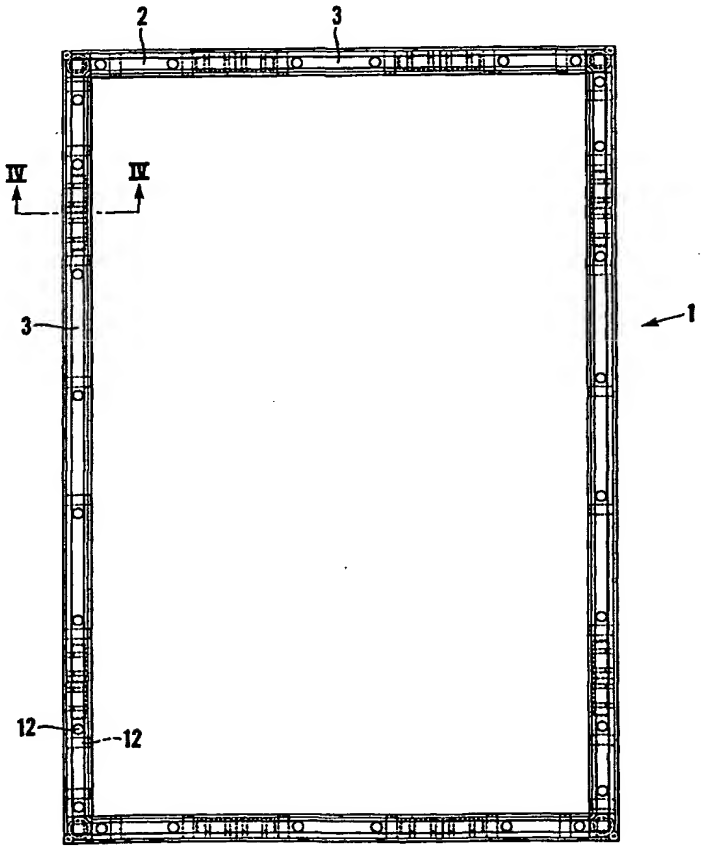
(54) Title: ENCLOSURE FOR HARDWARE

(57) Abstract

An enclosure (1) for conduction–cooled hardware comprises a frame of corner pieces (2) and intermediate linking pieces (3). The corner pieces (2) (and maybe the pieces (3)) are formed by casting and machining. Panels are added to this frame to complete the enclosure (1). The corner pieces (2) have projecting portions that project through a significant distance. A range of different–sized linking pieces is provided so that different–sized enclosures can be assembled.



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ENCLOSURE FOR HARDWARE

This invention relates to a conduction-cooled hardware enclosure and to a method of producing the same.

It is known to provide high-strength sealed enclosures for electronic hardware, where such hardware needs to be protected from the external atmosphere. The hardware in the sealed enclosure is cooled by conduction, the body of the enclosure having a low thermal impedance to carry heat from the hardware to the external atmosphere. The hardware needs to be protected from the external atmosphere in order, for example, to avoid moisture reaching the hardware. There are a number of known types of chassis for such an enclosure. One known chassis is produced by casting the chassis as one piece of metal. A second known chassis is formed of elongate pieces of machined metal that are attached together by screws to form the chassis and the chassis then dip-brazed at 1000°C in a salt bath. However, the production of either such chassis is undesirably expensive. A third known chassis is formed as per the second type, but without dip-brazing. The resulting chassis, however, is structurally weak, and if an enclosure made with such a chassis is dropped or suffers any other high impact then the chassis is likely to be distorted, with resulting damage to the enclosure.

GB-A-1512899 discloses a construction system for cabinets each comprising a framework covered with panels, which framework comprises elongate frame members which are releasably connectable together by means of connecting elements and connecting screws. The connecting elements include cubic corner elements which are each provided with three plug members projecting therefrom and adapted to engage within respective ends of the frame members, which may be made from a suitable steel alloy. The corner elements are formed by hot pressing in a suitable aluminium alloy.

According to a first aspect of the present invention, there is provided a conduction-cooled hardware enclosure comprising first and second sides opposite to each other extending in respective substantially parallel planes, each side comprising portions of at least one one-piece element of

thermally conductive material, said portions extending in the plane of the side, each element including a projecting portion extending towards the opposite side of said first and second sides, and fixing means fixing the projecting portion(s) extending from the first side to the projecting portion(s) extending from the second side, characterised in that the or each one-piece element is formed by casting and machining.

According to a second aspect of the present invention, there is provided a conduction-cooled hardware enclosure comprising first and second sides opposite to each other extending in respective substantially parallel planes, each side comprising portions of at least one one-piece element of thermally conductive material, said portions extending in the plane of the side, each element including a projecting portion extending towards the opposite side of said first and second sides, and fixing means fixing the projecting portion(s) extending from the first side to the projecting portion(s) extending from the second side, characterised in that said projecting portion has one or both of the following features:-

(i) said projecting portion extends into at least 5% of the spacing between said first and second sides, and

(ii) said projecting portion has a length at least equal to its own thickness.

According to a third aspect of the present invention, there is provided a conduction-cooled hardware enclosure comprising first and second sides opposite to each other extending in respective substantially parallel planes, each side comprising portions of at least one one-piece element of thermally conductive material, said portions extending in the plane of the side, each element including a projecting portion extending towards the opposite side of said first and second sides, and fixing means fixing the projecting portion(s) extending from the first side to the projecting portion(s) extending from the second side, characterised in that said fixing means comprise dowel means closely received in recesses formed in the projecting portions.

According to a fourth aspect of the present invention, there is provided a method of producing an enclosure for conduction-cooled hardware, comprising forming at least two one-piece elements by casting and machining, each element including projecting portions, and fixing together said projecting portions in assembling said enclosure.

Owing to these aspects of the invention, it is possible to provide a conduction-cooled hardware enclosure that is structurally strong, but can be manufactured relatively cheaply. The one-piece elements are relatively cheap to produce compared to casting an entire chassis, but still provide the requisite structural integrity.

According to a fifth aspect of the present invention, there is provided a method of producing a conduction-cooled hardware enclosure comprising providing a plurality of enclosure pieces of a range of differing sizes and usable in assembling enclosures of respective differing sizes, selecting some of those pieces, assembling a thermally conductive enclosure of a desired size and including the selected pieces and installing electronic hardware in said enclosure in thermally conductive communication with said enclosure.

Owing to this aspect of the invention, it is possible to construct easily conduction-cooled hardware enclosures of a range of differing sizes, by choosing the size of enclosure piece appropriate to produce an enclosure of the desired size.

In order that the invention may be clearly understood, and readily carried into effect, reference will now be made, by way of example, to the accompanying drawings, in which:-

Figures 1, 2 and 3 are respectively side, end and plan views of a chassis for a conduction-cooled hardware enclosure,

Figure 4 is a fragmentary end view of a detail of the chassis taken on the line IV-IV of Figure 3 showing two plates about to be fixed to the chassis,

Figure 4a is a perspective view of a corner piece of the chassis,

Figure 5 is a view similar to Figure 4 with the plates now fixed to the chassis,

Figure 6 is a fragmentary plan view of a join between two pieces of the chassis,

Figure 7 is a plan view of a piece of an alternative embodiment of the enclosure chassis,

Figure 8 is a side view of the piece of Figure 7, and

Figure 9 shows a section on the line IX-IX of Figure 7.

Referring to Figures 1 to 3, a chassis 1 is made up of six triskelion-form corner pieces 2 and joining pieces in the form of straight links 3. The corner pieces 2 are cast, each as one piece, in metal, e.g. aluminium, or carbon fibre and then machine-finished, particularly milled, to shape to achieve good orthogonal strength. The links are also made of metal, e.g. aluminium, or carbon fibre and may also be manufactured by casting and machine-finishing. Panels are fitted to the chassis by fixing them to the corner pieces 2 and/or the links 3. The panels are for cladding and act as heat sinks to conduct away excess heat from the electronic hardware that will be used in the enclosure in its working environment.

The corner pieces 2 (seen more clearly in Figure 4a) are formed with three projecting portions 2a each with a recess 2b in its end. The projecting portions 2a extend through a significant distance. To achieve the requisite structural strength, the portion 2a extends into at least 5% of the spacing between two sides of the enclosure 1 and/or has a length at least equal to its own thickness. Ideally the length of the portion 2a should be at least three times its own thickness. The same principle applies to the length of the projecting portion 21 of the plate-form casting 20 of Figures 7 to 9.

In Figure 4 two cladding panels 4 and 5 are shown about to be fitted to the chassis 1. The panel 5, in the form of a top cover has an internal portion 6 that mates with a section 7 of the chassis. Similarly the panel 4, in the form of a side plate, has a portion 8 that mates with a section 9 of the chassis. The panel 4 also has a portion 10 that is within

the chassis 1 and facilitates the heat sink properties of the enclosure. Each panel is supplied with respective holes 11 that each match up with respective holes 12 in the chassis 1 for accepting screws, e.g. of mild steel, for fastening the panels to the chassis 1.

Figure 5 shows the chassis 1 with the panels 4 and 5 now affixed. Each of the holes 12 is fitted with a heli-coil insert to provide a stronger thread in the hole that will then receive the screw to fix the panel in place. "O" ring seals 15, that are fitted between the panel 4 or 5 and the chassis 1, are provided to ensure a full hermetic and electro-magnetic emission seal. The machine-finishing of the pieces 2 (and the links 3) promotes good sealing of the enclosure 1.

Figure 6 shows a join between two pieces of a chassis. This join could be between two corner pieces 2, between two links 3 or between a corner piece 2 and a link 3. Owing to the universality of the join, any size of chassis can be constructed by choosing the length and number of links 3 appropriate to the size of enclosure required. Each pair of adjacent ends of the pieces 2 and 3 is formed with respective recesses closely receiving respective halves of respective dowels 16 preventing relative lateral movement of the ends of each pair. An anti-rotation pin 19 (seen in Figure 5) is present near a corner of one end of each pair and mates with a corresponding recess on the other end of each pair. This prevents the two ends of the pair from rotating relative to each other during final fixing of the dowel 16. The dowel 16 is held fixed relative to each end by two pairs of force-fit pins 17. The two pairs of pins 17 for each end are in respective planes at right-angles to each other. Between the two ends is an "O" ring seal 18 to help ensure an hermetic seal. The use of the pins 17 and dowel 16 enable a very tight tolerance to be achieved, which is necessary to obtain the hermetic seal.

In Figures 7 to 9 the chassis 1 is formed of two profiled, plate-form castings (of which one is shown and referenced 20) and, if desired, links 3 (according to the

version of Figures 1 to 6) therebetween. Each casting is a single piece of metal e.g. aluminium, with projecting legs 21 that are joined to the legs of the opposite casting (or the links 3) in the same manner as the corner pieces 2 are joined to each other or the links 3 in the previous embodiment. The plate-form castings (and the links 3) are machine-finished, particularly to promote good sealing of the enclosure 1.

CLAIMS

1. A conduction-cooled hardware enclosure (1) comprising first and second sides opposite to each other extending in respective substantially parallel planes, each side comprising portions of at least one one-piece element (2;20) of thermally conductive material, said portions extending in the plane of the side, each element (2;20) including a projecting portion (2a;21) extending towards the opposite side of said first and second sides, and fixing means (3,16,19) fixing the projecting portion(s) (2a;21) extending from the first side to the projecting portion(s) (2a;21) extending from the second side, characterised in that the or each one-piece element (2;20) is formed by casting and machining.

2. An enclosure according to claim 1, wherein said machining of the or each one-piece element (2;20) comprises machine-finishing of surfaces of the element (2;20) which constitute sealing surfaces of the enclosure (1).

3. An enclosure according to claim 1 or 2, wherein each one-piece element (2) is a triskelion-form corner piece (2).

4. An enclosure according to claim 1 or 2, wherein each one-piece element (20) is in the form of a plate-like piece (20) including projecting corner legs (21).

5. An enclosure according to any preceding claim, wherein said fixing means (3,16,19) comprises a plurality of fixing pieces (3).

6. An enclosure according to claim 5, wherein said fixing pieces (3) have been selected from a range of fixing elements comprising the selected fixing pieces (3) and other fixing elements of different lengths from the selected fixing pieces (3).

7. An enclosure according to any one of claims 3 to 6, wherein the pieces (2,3;3,20) have pairs of adjacent ends and wherein a plurality of dowels (16) are closely received in recesses (2b) formed longitudinally of the ends of the respective pairs of adjacent ends and are fixed against longitudinal movement relative to the receiving ends.

8. An enclosure according to any preceding claim, wherein

said projecting portion (2a;21) has one or both of the following features:-

(i) said projecting portion (2a;21) extends into at least 5% of the spacing between said first and second sides, and

(ii) said projecting portion (2a;21) has a length at least equal to its own thickness.

9. An enclosure according to any preceding claim, and containing conduction-cooled hardware in thermally conductive communication with said enclosure.

10. A conduction-cooled hardware enclosure (1) comprising first and second sides opposite to each other extending in respective substantially parallel planes, each side comprising portions of at least one one-piece element (2;20) of thermally conductive material, said portions extending in the plane of the side, each element (2;20) including a projecting portion (2a;21) extending towards the opposite side of said first and second sides, and fixing means (3,16,19) fixing the projecting portion(s) (2a;21) extending from the first side to the projecting portion(s) (2a;21) extending from the second side, characterised in that said projecting portion (2a;21) has one or both of the following features:-

(i) said projecting portion (2a;21) extends into at least 5% of the spacing between said first and second sides, and

(ii) said projecting portion (2a;21) has a length at least equal to its own thickness.

11. An enclosure according to claim 10, wherein each one-piece element (2) is a triskelion-form corner piece (2).

12. An enclosure according to claim 10, wherein each one-piece element (20) is in the form of a plate-like piece (20) including projecting corner legs (21).

13. An enclosure according to claim 10, 11 or 12, wherein said fixing means (3,16,19) comprises a plurality of fixing pieces (3).

14. An enclosure according to claim 13, wherein said fixing pieces (3) have been selected from a range of fixing elements

comprising the selected fixing pieces (3) and other fixing elements of different lengths from the selected fixing pieces (3).

15. An enclosure according to any one of claims 11 to 14, wherein the pieces (2,3;3,20) have pairs of adjacent ends and wherein a plurality of dowels (16) are closely received in recesses (2b) formed longitudinally of the ends of the respective pairs of adjacent ends and are fixed against longitudinal movement relative to the receiving ends.

16. An enclosure according to any one of claims 10 to 15, and containing conduction-cooled hardware in thermally conductive communication with said enclosure.

17. A conduction-cooled hardware enclosure (1) comprising first and second sides opposite to each other extending in respective substantially parallel planes, each side comprising portions of at least one one-piece element (2;20) of thermally conductive material, said portions extending in the plane of the side, each element (2;20) including a projecting portion (2a;21) extending towards the opposite side of said first and second sides, and fixing means (3,16,19) fixing the projecting portion(s) (2a;21) extending from the first side to the projecting portion(s) (2a;21) extending from the second side, characterised in that said fixing means comprise dowel means (16) closely received in recesses (2b) formed in the projecting portions (2a;21).

18. An enclosure according to claim 17, wherein said recesses (2b) are substantially co-axial with said projecting portions (2a;21).

19. A method of producing an enclosure (1) for conduction-cooled hardware, comprising forming at least two one-piece elements (2;20) by casting and machining, each element including projecting portions (2a;21), and fixing together said projecting portions (2a;21) in assembling said enclosure.

20. A method according to claim 19, wherein said machining comprises machine-finishing of surfaces of the elements (2;20) which constitute sealing surfaces of the enclosure (1).

21. A method of producing a conduction-cooled hardware enclosure (1), comprising providing a plurality of enclosure pieces of a range of differing sizes and usable in assembling enclosures of respective differing sizes, selecting some (3) of those pieces, assembling a thermally conductive enclosure (1) of a desired size and including the selected pieces (3) and installing electronic hardware in said enclosure (1) in thermally conductive communication with said enclosure (1).

22. A method according to claim 16, and further comprising providing pieces (2) of a standard size and each a triskelion form corner-piece (2), and including the latter pieces (2) in said enclosure (1) during assembly of said enclosure (1).

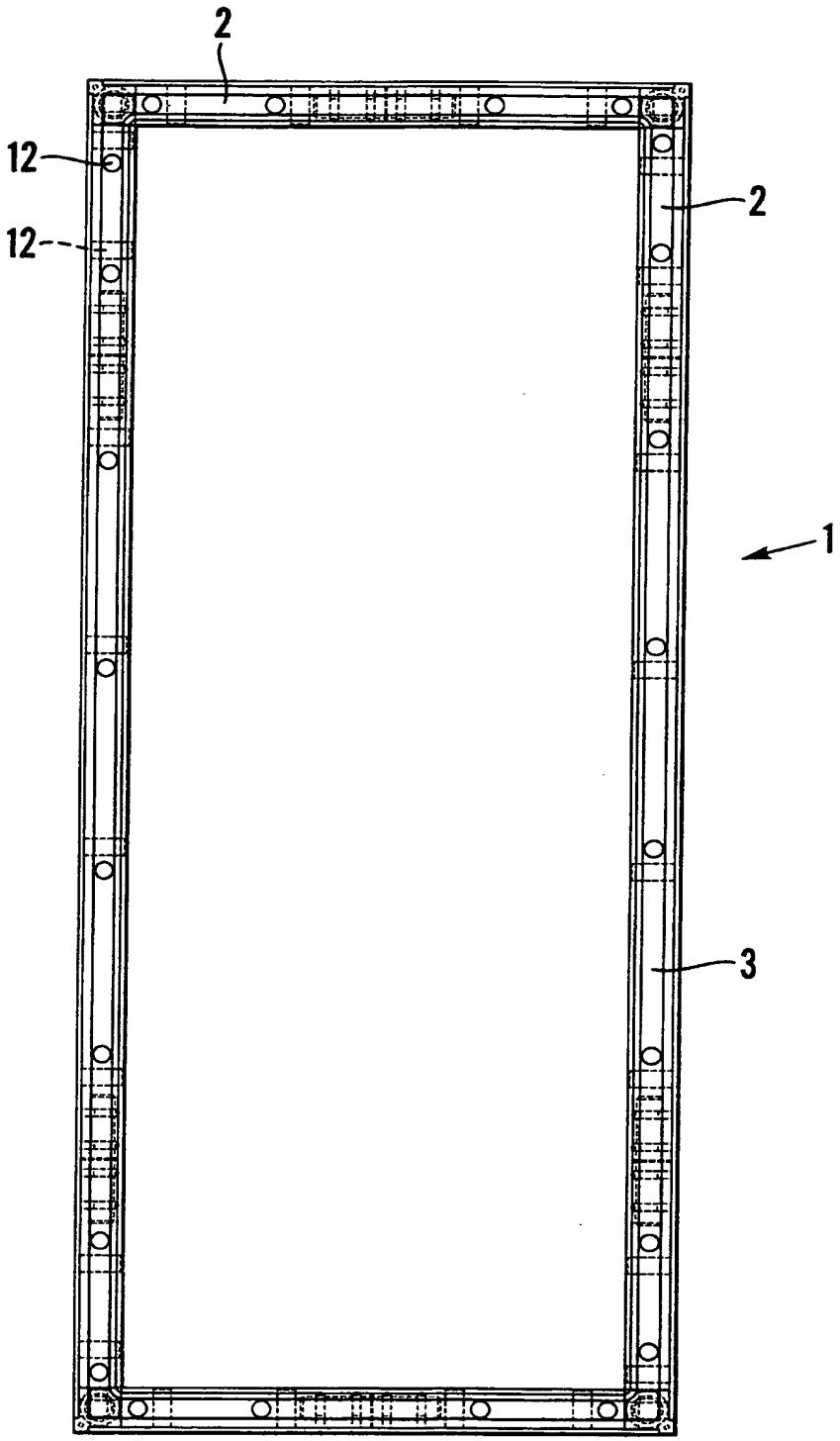


Fig. 1

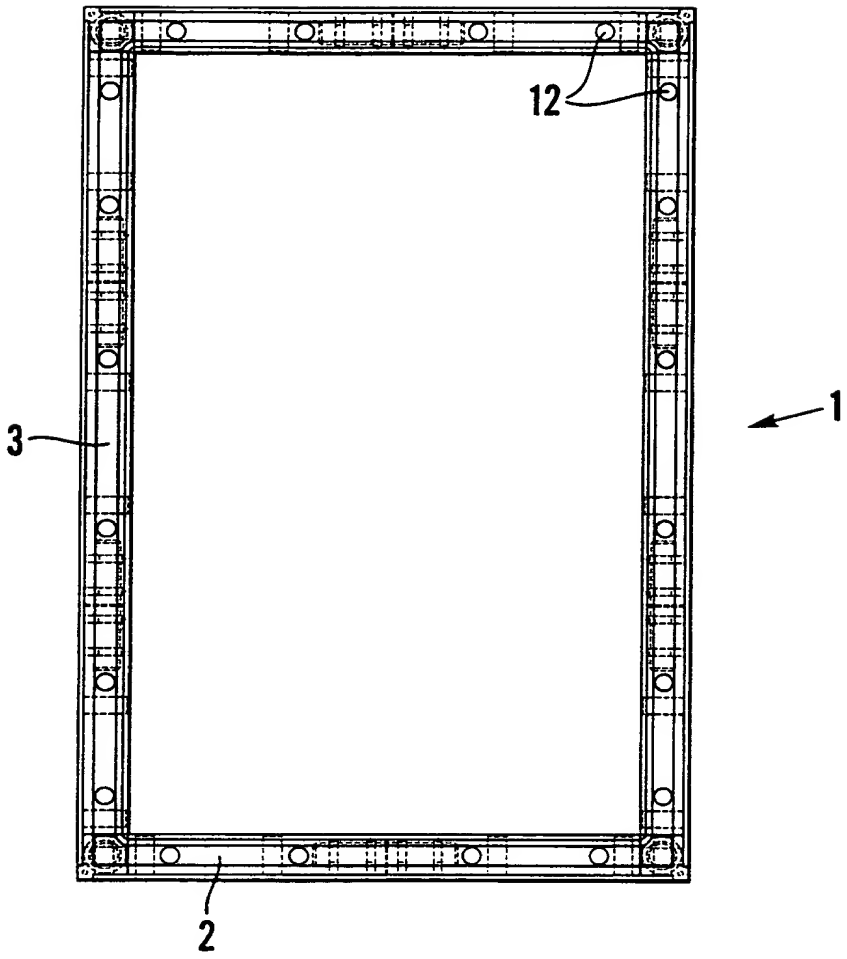


Fig.2

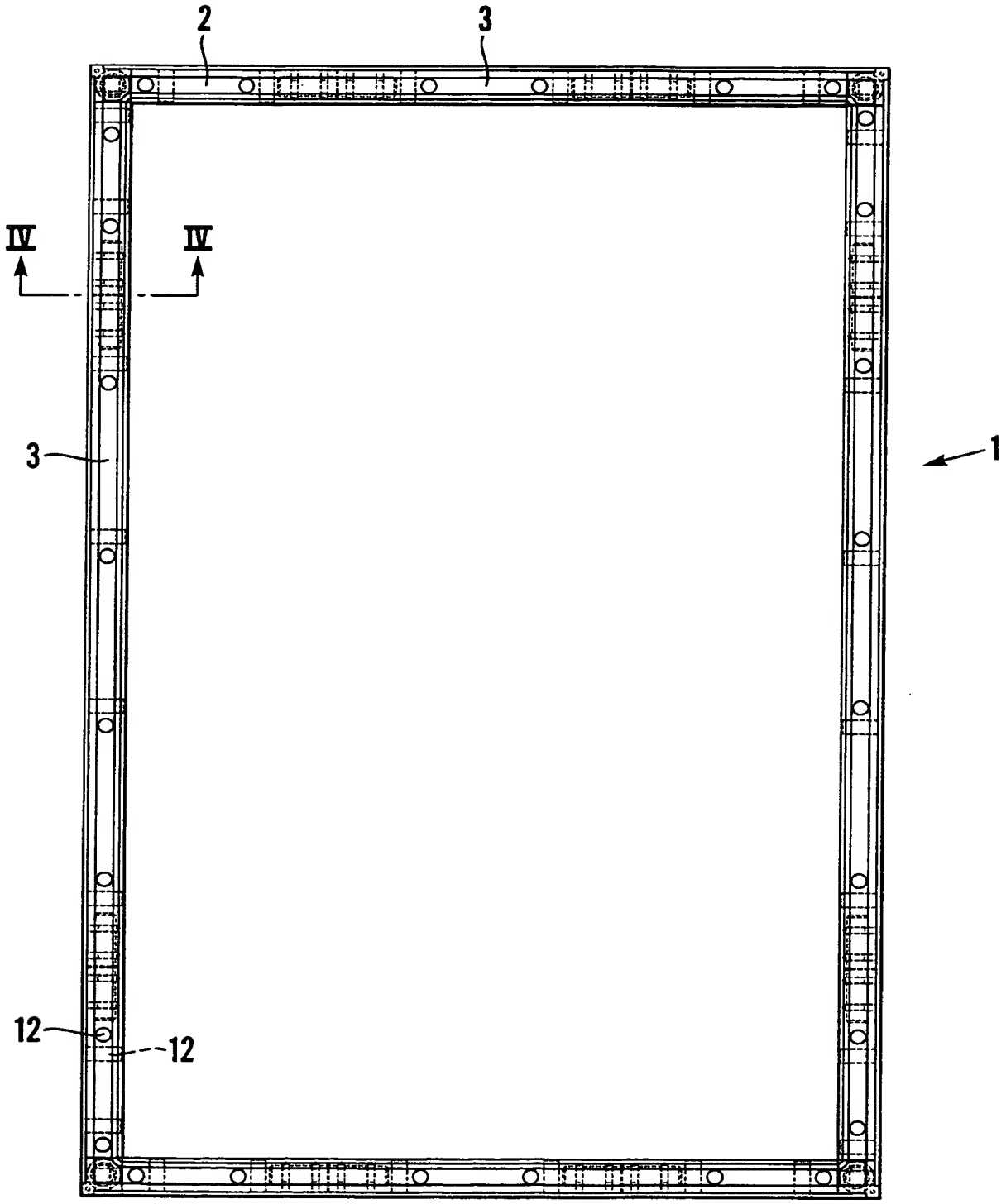


Fig.3

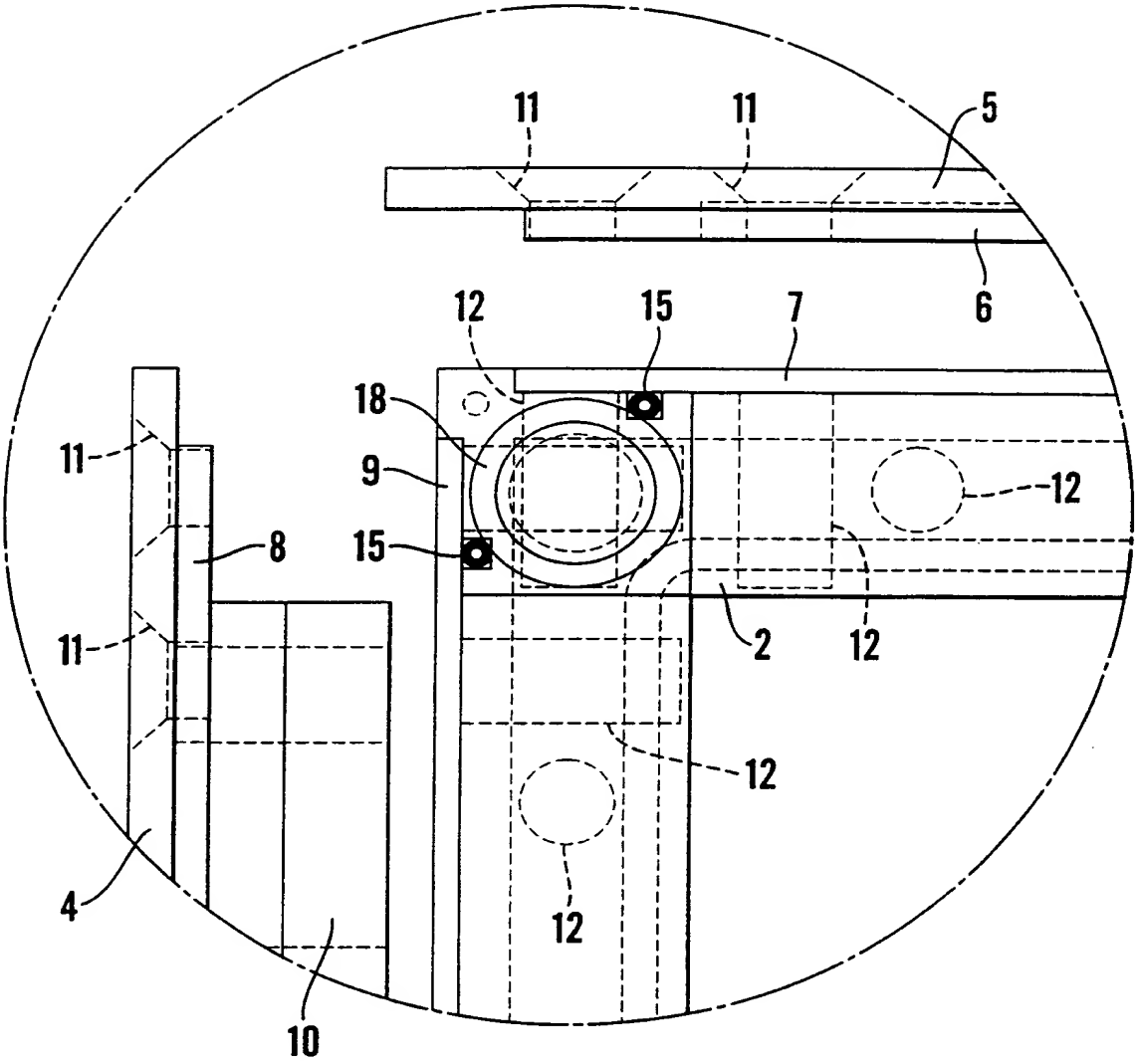


Fig.4

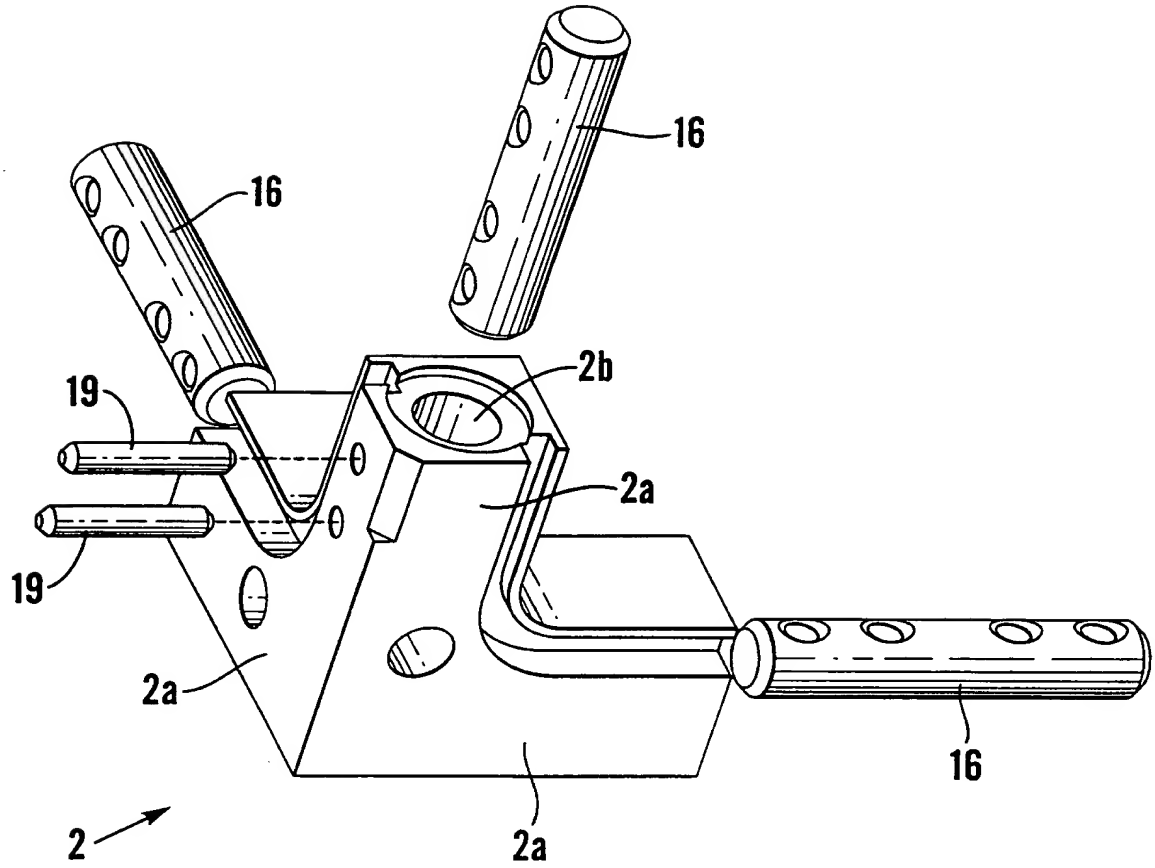


Fig.4a

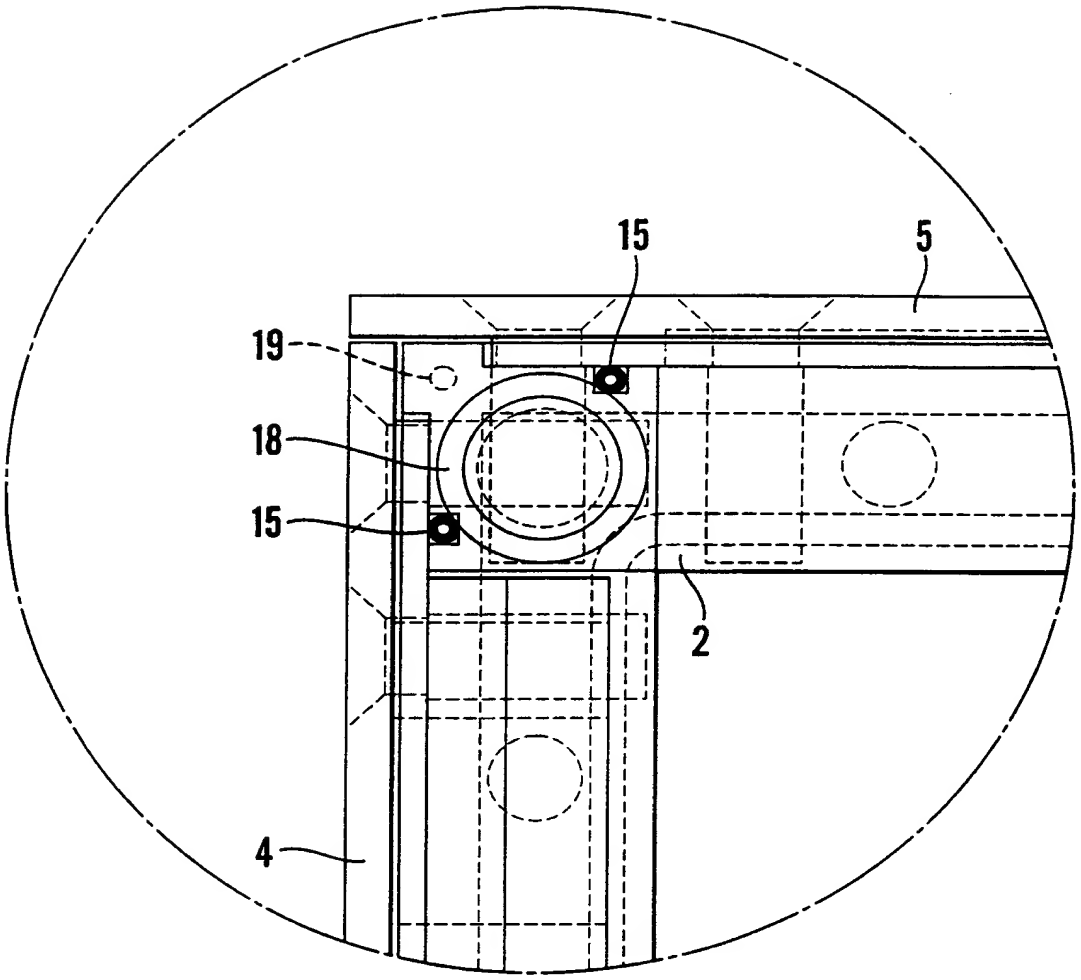


Fig.5

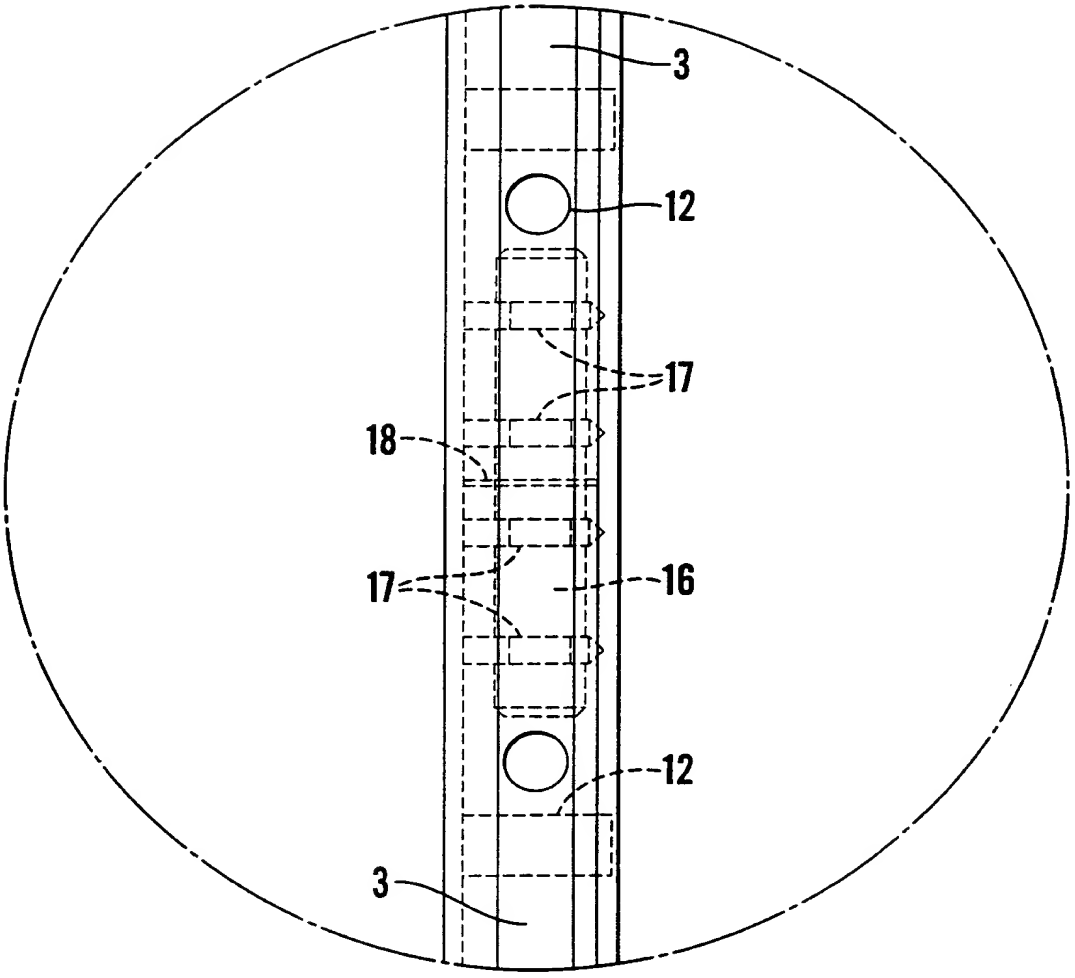


Fig.6

Fig.7

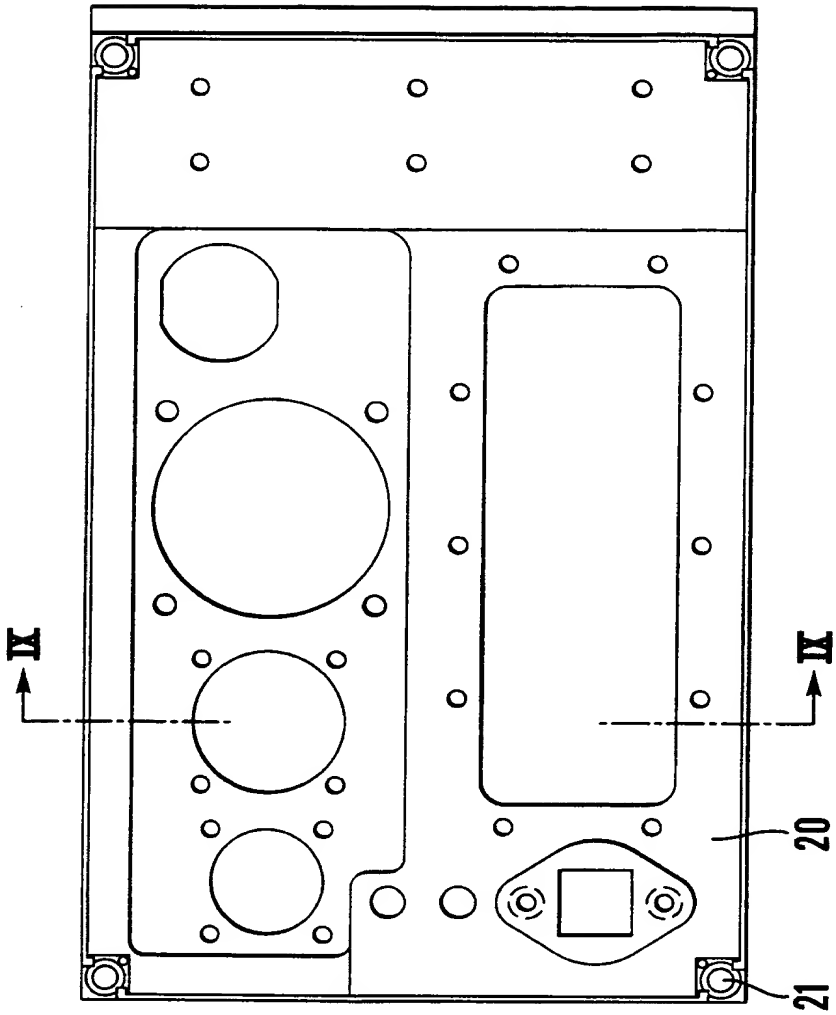


Fig.8

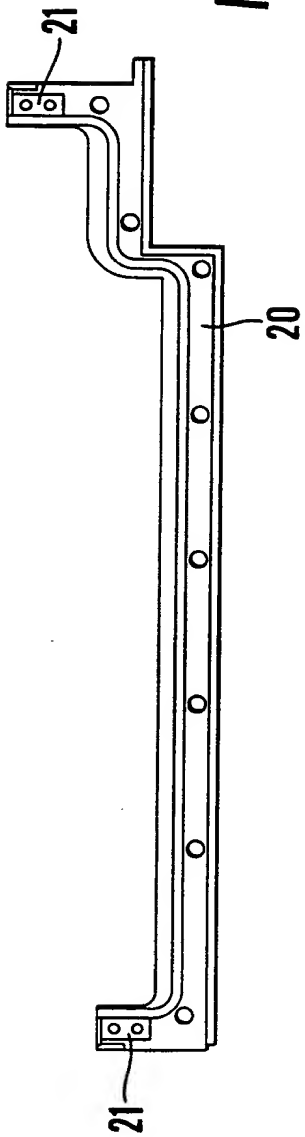
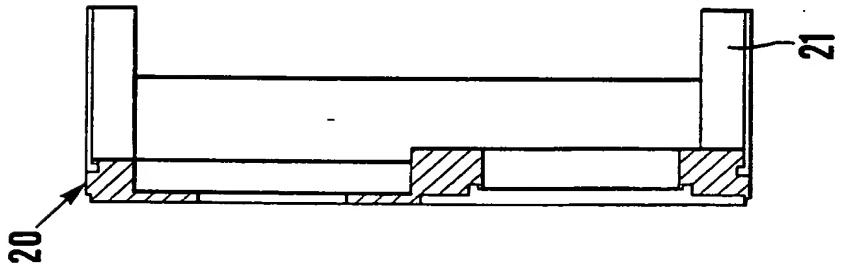


Fig.9



INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 00/00950

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H02B1/30

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H02B A47B F16B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4 691 970 A (NERI ARMANDO) 8 September 1987 (1987-09-08) the whole document	1,10,17, 21
A	DE 44 39 622 C (LOH KG RITTAL WERK) 23 November 1995 (1995-11-23) column 3 -column 4	1,10,17, 21
A	EP 0 762 819 A (LEGRAND SNC ;LEGRAND SA (FR)) 12 March 1997 (1997-03-12) the whole document	1,10,17, 21

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
15 June 2000	22.06.00

Name and mailing address of the ISA	Authorized officer
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Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/GB 00/00950

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. [ ] Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. [X] Claims Nos.:
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:
see FURTHER INFORMATION sheet PCT/ISA/210

3. [ ] Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. [ ] As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.

2. [ ] As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. [ ] As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:

4. [ ] No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

[ ] The additional search fees were accompanied by the applicant's protest.

[ ] No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

Continuation of Box I.2

The idependant claims 1,10 and 17 do not describe clearly what is claimed for the following reasons:
- Reference (1) relates to an enclosure in claims and to a chassis in the description.
- It is difficult to see and enclosure with only 2 parallel sides as described in claims
- The meaning of "...each side comprising portions of at least.....extending from the the second side.." does not make sense as it is not possible to relate the 1-3 drawings and the 7-9 drawings.
From the drawings it is unclear how the chassis, the panels and the links are assembled together to built an enclosure.
- The word triskelion seems inapropriate because it covers any plane figure with 3 radiating branches.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/GB 00/00950

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